

**Dr. Ballard's Report to the Local Government Board upon
an Outbreak of Diphtheria in a Cottage adjoining the
Churchyard at Trotterscliffe near Wrotham, Kent.**

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Medical Department,
July 10th, 1880.

The occasion of this inquiry arose from a report which Dr. Baylis, the Medical Officer for West Kent combined district, had made to the Local Authority on October 21st, 1879, upon a late occurrence of very fatal diphtheria in a family occupying a cottage adjoining the churchyard of Trotterscliffe. On September 29th the family of Mr. Jones, residing at the cottage, numbered 14 persons, but of these seven had died of diphtheria (as was believed) by October 11th. There was no question of sanitary administration involved; the inquiry was made simply with the object of ascertaining anything that might be discoverable, to assist in elucidating the mode of origin of this disease.

The inquiry and this Report are not to be regarded as completely demonstrating the origin of the outbreak. Some questions of etiology are raised which, so far as I know, have not been raised before—questions which, it will be obvious, require for their solution similar experimental investigations in other instances and in various directions.

The rough plan No. 1. (not drawn to scale but sufficiently accurate for this purpose) indicates the situation of the cottage A in relation to its immediate surroundings.

Originally (a good many years ago) what is now one cottage was three cottages *a*, *b*, and *c*, having a stable *d* at the east end and a coach-house *e* at the west end. Now, *a*, *b*, *c*, and *d* are all parts of the one cottage, and the ground-floor rooms communicate by doorways as shown in the plan:—*e* is still a coach-house. Each of the rooms shown, and the coach-house also, has a room above, so that there are five rooms on the upper floor. Of these five rooms, two at the west end are approached by a staircase from *c*, and the three at the east end by a staircase from *a*.

Plan No. 2 shows on a larger scale the arrangements of the rooms, both on the ground and upper floor.

On the ground floor, at the time of inquiry, *c* was used mostly as an office; *b* was the kitchen with a wide fireplace *m*, a sink *k* and cupboard *l* in the corner and occupying the whole height of the room; *a* and *d* were sitting-rooms; *a*, *b*, and *d* were used indiscriminately by the family in the daytime; *a* and *b* were entered directly from the road by doorways represented in the plan; *c* had also a door from the outside, but it was habitually closed; *a*, *b*, and *d* had also fireplaces *m*. There was a window capable of being freely opened in the front wall of each room.

On the upper floor the three rooms *f*, *g*, and *h*, used habitually as bedrooms for the family, were approached by a staircase directly from *a*, and the door at the foot was habitually open at night; *f* and *g* were entered from the landing at the top of the staircase, and *h* was entered from *g*. Each room had a window, capable of being freely opened, in the front wall:—*f* alone had a fireplace *m*, the chimney of which was habitually open in the summer time, but was stuffed up in the winter:—*i* and *j* were not occupied as bedrooms.

The back wall of the house is formed below by the actual wall of the churchyard, and the floors of the ground-floor rooms are about four feet below the level of the churchyard. To this height or thereabouts the back wall of the ground-floor rooms is damp, and this dampness is especially obvious in the room *d*; the east wall of *d* is also damp to about the same height. Against this wall is the privy *n*, which is a brick ashpit privy; it was put there a few years ago, but the wall was damp previously. The floor of *b* is boarded. On examining the floor boards I found that they had become rotten all round next the walls, and that cement had been filled into the space where they had rotted away. I had a plank raised along the east wall, and found

the joists laid upon the earth, which was damp but not offensive. There were numerous mouse-holes and mouse-runs visible beneath this plank and against the wall. The dotted line in *d* shows where the plank was raised.

The sink *k* has only been used, it is said, for washing and other inoffensive domestic slops; chamber slops were always carried to the privy. The strainer indicated was without any bell trap, and the water ran through it into a vertical $4\frac{1}{2}$ -inch salt-glazed pipe which communicated through the wall below with a similar socketed pipe laid about a foot beneath the surface of the ground, and which ran uninterruptedly a distance of 50 feet, as shown by the dotted line, to its outfall about one foot above the surface of the field on to which it discharged its contents. The fall in the course of this 50 feet is $3\frac{1}{2}$ feet. The pipe, where I examined it near the house, was free from deposit. There was no catchpit in its course.

The cupboard *l* is a deal painted cupboard with shelves, and has been habitually used to contain the food of the family. It is a very old construction, a good deal decayed in the back part and sides, where there are mouse-holes, some of which had been covered with a plate of tin nailed over them and one of which had been stopped with a cork, but there were still openings by which mice could get in. I had this cupboard pulled out from the corner. Behind it were black sooty cobwebs which had entangled various dusty matters, and there was also mouse-dung. In the floor behind was a large mouse-hole. The interior of the cupboard had a disagreeable smell.

Prior to the illnesses about to be described, the family of Mr. Jones, who is farm bailiff to Mr. Pine, had suffered no serious illness, and on September 28th consisted of the following persons, viz. :—

Mr. Jones	-	-	aged 49 years.
Mrs. Jones	-	-	„ 42 „
James	-	-	„ 17 „
Ann Elizabeth	-	-	„ 15 „
Sarah Ann	-	-	„ 13 „
Emily	-	-	„ 9 „
Edwin	-	-	„ 8 „
Edith	-	-	„ 7 „
William Henry	-	-	„ 6 „
Mary	-	-	„ 4 „
Ellen	-	-	„ 3 „
Thomas Frederick	-	-	„ 1 year 11 months.
Madeleine	} twins	-	„ 3 months.
Winifred			

Mr. Jones, who is “asthmatic” and cannot sleep in the recumbent posture, habitually sleeps in an easy chair in one of the ground-floor rooms. The other members of the family slept at night distributed in the upstairs rooms, as follows :—

In *f*. Mrs. Jones, the twins and either Ellen or Thomas, together in one bed.

In *g*. James, Edwin, and William Henry in one bed.

In *h*. Sarah, Emily, and either Ellen or Thomas in one bed, and Ann Elizabeth, Edith, and Mary in another bed.

The dimensions of *h*, the ventilation of which room was exceptionally defective, are $15 \times 13 \times 7$ feet = 1365 cubic feet = 227 feet per head.

So much for the house—now for its surroundings.

The locality represented on the plan No. 1 is lower considerably than the village situated about one furlong to the westward (the parsonage and its grounds intervening). The soil on the surface is dry, with chalk a few feet below it. The lowest spot in the immediate vicinity of the cottage is the duck-pond and the ground at the rear of the granary where water commonly lies, as represented on the plan. It is on to this part that the drain from the cottage discharges. There is a channel (now choked up with offensive sewage deposit) leading from the drain outlet by the side of the wall of the cart-shed to the duck-pond, but the ground all about this corner of the field is sodden with sewage and devoid of grass. A row of tall trees bounds the roadway to the east. The whole locality is low and habitually damp. But there is lower land still to the south of the bend of the road. The granary is overrun with rats which have burrowed from it beneath the floor of the cart-shed, and

from the meadow rat-holes in abundance are visible along the base of the cart-shed wall as it abuts the meadow. It was plain that the rats frequently ran over the swampy corner of the meadow behind the granary.

The only house near is that of the farmer Mr. Pine. It is a large house but very damp. Mr. P. and his family, consisting of his wife and six daughters varying in age from 12 to 22, reside there only during the summer months. They were there during the illnesses at the cottage. The farmyard and buildings are represented on the plan. The fowl-house was clean at the time of my visit; Mrs. Jones attended habitually to the fowls. The fowls' dung is habitually conveyed to Mr. Pine's garden by the gardener and used there. The cows (two) are kept in the daytime in the meadow, but are brought into the cowhouse to be milked. No cows had calved since April. The cowhouse is dry, and, with the exception to be mentioned, clean. At the north end of it stands raised above the ground a cage containing a ferret. The cage is of the shape of a rabbit-hutch, but the floor of it as well as most of the front is constructed of iron rods so as to ensure its dryness. In the corner marked X I observed a little heap of greenish curdy-looking matter rising about $3\frac{1}{2}$ inches from the floor of the cage and partly protruding between the bars. On the outside it was mouldy. Some similar matter hung down from the rods forming the floor in this situation. I found by watching the ferret that this was the spot where it urinated and defecated by preference. It turned its tail towards this corner and squirted out its excreta with great violence. Some straw lying on the ground beneath the cage was saturated with this filth. The gardener, who, with his wife, lives at Mr. Pine's house, milks the cows, and after milking them fills a little earthen pan with new milk and puts it into the ferret's cage. He then carries away the milk to the dairy (clean and wholesome) at Mr. Pine's house. Mrs. Jones says that her children were forbidden to go further to the westward than the cottage, and habitually played about an old pound situated among the trees to the eastward of the road and duck-pond.

The water drunk by Jones' family is from a well (with pump) at the rear of Mr. Pine's house. The water is regarded as good, and is habitually drunk also by Mr. Pine's family.

Professor Voelcker made an analysis of this water on October 16th, 1879, and obtained the following result. In an imperial gallon he found—

Solid constituents dried at 130° C	-	-	-	grain 31.92
(consisting chiefly of carbonate of lime, and some sulphate of lime and carbonate of magnesia, and including)				
Oxidisable organic matter	-	-	-	.179
Chloride of sodium	-	-	-	2.99
Nitric acid as nitrates	-	-	-	4.02
It further contained:				
Actual (saline) ammonia	-	-	-	.001
Organic (albuminoid) ammonia	-	-	-	.005
Hardness on Clark's scale	-	-	-	$23\frac{1}{3}$

He adds "the water was clear, colourless, and free from smell. The residue that was left on evaporation to dry near was white, and turned only slightly dark on exposure to a strong heat. The water contained not more saline and organic ammonia than usually occurs in good and wholesome waters." The water at this time was not in such a condition as to render it probable that its use for drinking had anything to do with the origin of the disease.

Mrs. Jones says that she is as careful as possible always to prevent much communication with the village. They keep as much as possible to themselves. Prior to the illnesses they had none of them visited or been visited by persons from other villages. The children had had no new clothes recently, nor any old clothes of other persons newly made up. No alteration had been made in the arrangements of the rooms, no shifting of beds, &c.

The milk used by the family was mostly skimmed milk, of which Mr. Pine allowed them to have as much as they liked, and all the children drank it when they felt disposed. It used generally to stand on the table

in *d.* "unless people were about," and then it was commonly put into the cupboard with the other food. The infants (twins) were allowed new milk from Mr. Pine's dairy.

In the latter part of August and during September measles was prevalent in the village and among the children attending the parish school. The first cases occurred in a family named Nott, who had in July come from Fairseat, and who had acquired measles by visiting subsequently a family which had the disease in a neighbouring village. The Nott children were absent from school on account of measles on August 11th. It subsequently spread in the village, and there were numerous cases when the Jones family were suffering from measles. All who were attacked are said to have had more or less severe coryza, and many of them a slight amount of sore throat; but inquiring in the village I only heard of one case that required any special domestic treatment on this account. The cases, with only one or two exceptions, had no medical attendance. The sore throat in all the cases accompanied the coryza and ceased with the eruption. No sore throat *after* the measles. Nor did I hear of any remarkable external swellings about the throat, although I inquired; nor did I hear of any cases of sore throat independently of measles. Some cases of measles had no sore throat.

Between 3rd and 9th September such of the Jones family as had not had measles formerly were (with the exception of the twins) attacked with it. All had marked coryza; the mother says, "their noses were dirty, and they looked as if they had been crying." She says there was no remarkable sore throat. For dates of attack see Table A.

School broke up on September 5th, on which day none of the Jones' children, except Sarah Ann and Emily, were present at the "breaking up" school feast. The children who habitually attended school were Sarah Ann, Emily, Edwin, Edith, William, Henry, and Mary.

The first child attacked with sore throat was Emily. She had no medical attendance. For some days prior to Sunday, September 14th, she had been employed in the harvest field making "bands." Other village children were there also. She may have taken cold. She carried her dinner with her to the field, but had her other meals at home. She had no communication with other villages, nor with persons from other villages. *On September 15th*, while in the field, she felt ill, and came home in the evening with her throat sore. She continued ill with the sore throat for about a fortnight, but did not keep her bed; she came downstairs and mingled with the other children. After the death of the twins she, with Sarah Ann, went to stay at the Rectory. The mother says that at one time there was a good deal of discharge from her throat. But there was no eruption at any time on her skin. When Dr. Prall first visited the family on September 29th she was, he says, looking ill and her eyes were sunken, the throat was congested, but no membrane was observable. She was recovering.

On September 28th (Sunday) the mother says that Mary was flushed and evidently not well in the evening. She lolled and lay about. The twins had been fretful and crying unusually ever since the 27th, and she thought she would that Sunday night put a mustard poultice on their chests. Having made more poultice than she wanted, she put one also upon Mary [perhaps this may have been on account of the "croupy" symptoms she had had after measles]. At about 2 a.m. on 29th, Mary awoke with croupy breathing and "convulsions." She was "black in the face" with dilated nostrils. Dr. Prall was sent for and came. He says he could perceive no membrane on the throat, and there was no eruption on the skin. She died about 6 p.m. on 29th. [This case, standing alone, might have been regarded therefore as a case of "croup."]

On September 29th, when Dr. Prall saw Mary, he also saw the twins. He says that a reddish serum was running from their noses. He examined their throats. On that of Madeleine there was some thin diphtheritic membrane. Winifred's throat was red, but there was no membrane. Dr. Baylis saw Winifred on October 3rd, and could see no membrane. Madeline died on October 2nd, and Winifred on 3rd October. Both died apparently from "asthenia."

On September 30th Dr. Prall saw Thomas Frederick. He says he had at that time an eruption on his skin distinct and dark coloured, both on face and trunk, but no coryza. He recognized it as the eruption of "*Rubeola notha*,"

with which disease he says he is very familiar. There was, he says, deep ulceration of the throat, and the glands about the jaw were enlarged. He saw him again for the last time on October 1st. There was then no membrane on the throat, and his respiration was not croupy. He then advised the parents to send for Dr. Pope, the parochial medical officer, and ceased his own attendance. Dr. Pope says he first saw this child, with Edith, Ann Elizabeth, and James, on October 5th; there was no eruption on any of them, but on *all* the diphtheritic membrane was obvious, covering both the tonsils and the uvula. Thomas Frederick *died* on October 6th.

On October 5th Dr. Pope saw the sick children Ann Elizabeth, James, Edith and William Henry for the first time, and says they all had diphtheritic membrane, so that they were probably ill before that day. He says that on James there were only a few patches of membrane, but that all were cases of diphtheria. They died (with the exception of James, who recovered) on the days mentioned in the Table.

In the absence of any infection traceable by strict inquiry from outside, it would appear probable that Emily's case at least had a local origin, either in the harvest field or in the house. The other cases might have received infection from her or from one another.

As regards Ann Elizabeth, the mother and Dr. Pope both say that four days before her death she was apparently convalescing, and Dr. Pope's son saw her eating her breakfast and a chop with some appetite. It appears from the mother's statement that towards the end of the meal she was suddenly seized with "convulsions" and croupy breathing, pallor, and faintness. This was on Tuesday, October 7th. She says that such fits occurred at short intervals daily until she died. She vomited also soon after taking any food, so that at last she was fed by means of beef-tea enemata. After coming out of any of these so-called "fits" her face used to flush. Dr. Pope's certificate was "Diphtheria, 16 days. Thrombosis, 4 days."

There had been no burial in churchyard for seven months before the outbreak at Jones' family.

I learn from Dr. Baylis, the Medical Officer of Health, that, so far as he is able to learn, the family of Mr. Pine suffered from no form of illness whatever, and that sore throat has not prevailed at all in the parish since the fatal illnesses in Mr. Jones' family.

For some time past there has been growing up in my mind a notion that possibly, in those instances of apparently spontaneous origin of diphtheria which are often met with, the specific contagion of the disease may have been derived in some way from the lower animals, and especially from animals which are regarded as domestic vermin, such as rats, mice, blackbeetles, &c., about which and about the diseases of which there is scant knowledge or no knowledge at all.

I therefore brought away with me for further investigation the following matters:—1. A sample of water from the duck-pond. 2. Some of the drainage mud that lay in the channel behind the granary and cart-shed. 3. Mouse-dung found entangled in cobwebs behind the cupboard *l.* 4. Portions of old sooty cobweb from behind the cupboard *l.* 5. Some of the ferret's dung.

These things were collected on the 4th, 5th, and 6th of November, and on November 11th, I handed them over to Dr. Klein for experiment. His reports of his experiments with these several matters are appended:—

DR. KLEIN'S REPORT ON EXPERIMENTS UPON RABBITS made with Substances from Trotterscliffe.

November 15, 1879.

I have examined all the samples left with me, and have not found in them anything of a special character, as far as the microscopic examination goes. I have inoculated rabbits with those different materials and have obtained striking results, at any rate for the present. Of the material inoculated I produced with the drain-matter [the mud from the channel behind the cart shed] and the mouse's dung in two rabbits (one a piece) death in consequence of a disorder quite similar to that resulting from inoculating rabbits with diphtheritic matter.

With the pond water and cobweb I have not obtained any result.

December 2, 1879.

I have now made a sufficiently great number of inoculations to be able to say something positive about the infective property of the material given to me for examination.

As far as the microscope is concerned, I have not been able to see in any of the samples anything peculiar to them; for all of them contained, as might easily be expected, bacteria of many different kinds, and some of them (water from the pond and the mud from the drain-channel) in addition higher fungoid organisms.

The experiments of inoculation carried out on rabbits yielded the following results:—

(I may at the outset state that the inoculations were made with infinitesimal doses into the conjunctiva, which to my experience is more susceptible than the skin or the mucous membrane of the mouth. I mention this in order to show that a negative result of the inoculations is as true as—if not truer than—an inoculation into the skin or other parts.)

1. Inoculation (13th Nov.) with pond water, 2 rabbits; no result.

2. Inoculation (13th Nov.) with drain-mud, 2 rabbits. One rabbit died after 40 hours, the appearances were such as to warrant the diagnosis of a sort of septicæmia. Quantities of long cylinders were found in the urine of the bladder; this was thick and brown and contained those cylinders in the form of larger or smaller whitish flakes and threads. The mucous membrane of almost the entire small intestine was easily peeled off in flakes, and was covered with thick muco-purulent matter. Mucous membrane of larynx, trachea, and bronchi much injected and shows hæmorrhage, especially about the entrance of the larynx. Palate and pharynx swollen, injected and covered with an exudation-membrane. Thus it appears, that this disease differed materially from ordinary septicæmia in rabbits, inasmuch as there were here certain appearances of the pharynx and larynx and intestine which are not, to my knowledge, observed in rabbits when inoculated with septicæmic material. The blood of the above animal was crowded with very minute bacteria, and when inoculated, in infinitesimal doses, into the conjunctiva of two healthy rabbits, produced death in both animals. The appearances of them were very similar to those of the above animal.

3. Inoculation with mouse's dung, (13th Nov.) two rabbits. One died after 40 hours. The appearances were the same as in rabbit (2), except that the urine did not show any alteration. The blood of this animal was likewise crowded with bacteria and had infective properties.

4. The other materials, cobweb and ferret's dung, did not produce any positive result when inoculated into rabbits, two for each.

Since these first inoculations, I have repeated the inoculations with the drain-mud and mouse's dung in several animals, but have failed to produce anything; and this seems to me to give additional importance to the above-named positive results, for it proves that there was something present in those substances which has since lost its activity; further, that this "something" was not anything belonging to drain-mud or mouse's dung per se; these substances, as far as I am aware, do not produce any such results when inoculated into rabbits in infinitesimal doses; and, if they did, I do not think it probable that they would lose this power after being kept.

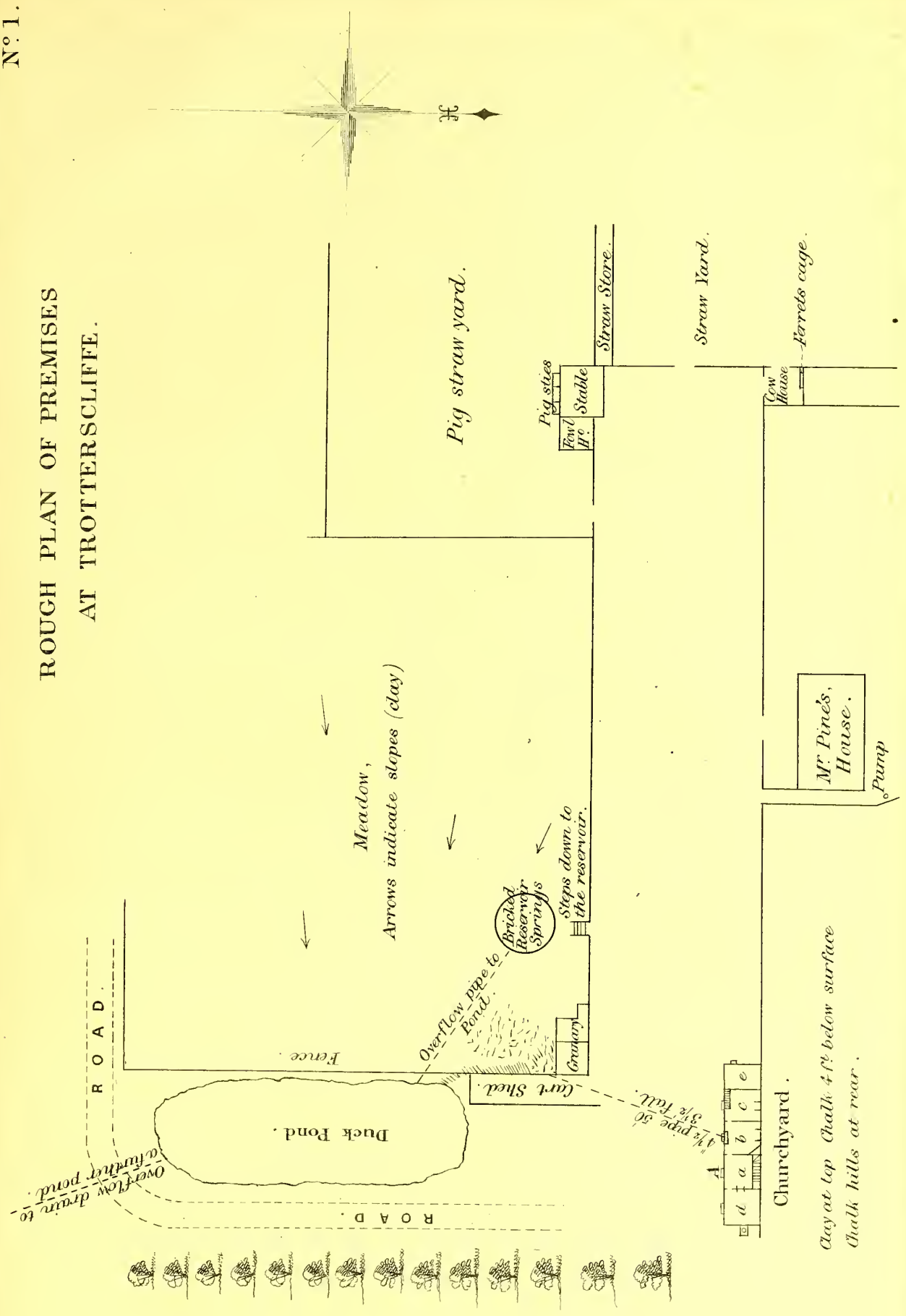
The results of Dr. Klein's observations and experiments appear to indicate that this line of inquiry is worth pursuing systematically. I am not disposed to say more than this.

March 15th, 1880.

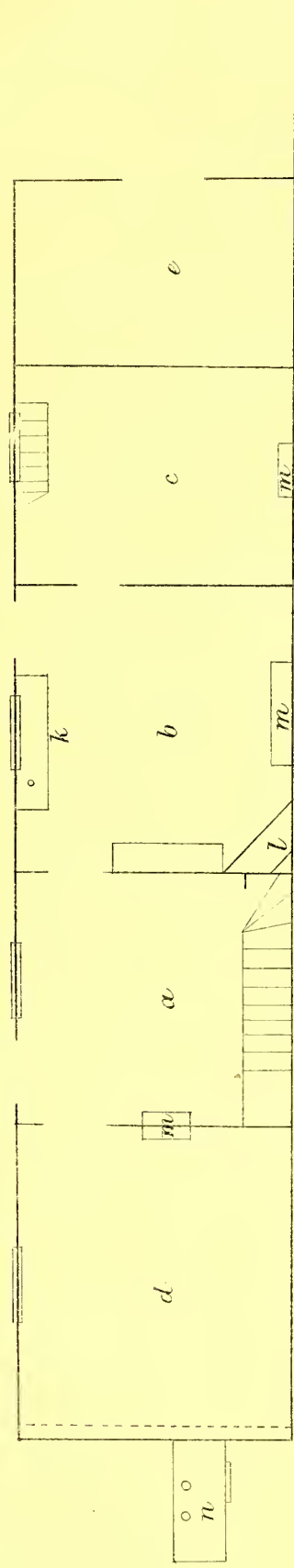
EDWARD BALLARD.

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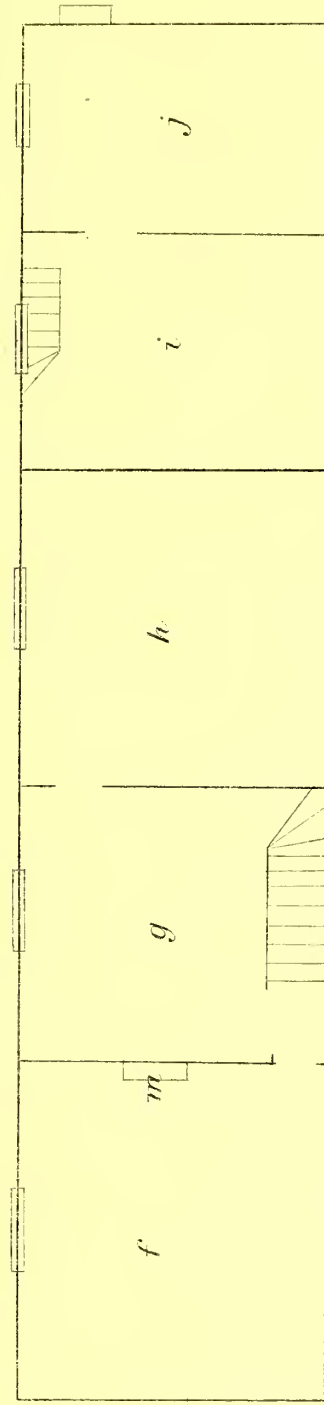
ROUGH PLAN OF PREMISES
AT TROTTERSCLIFFE.



Nº 2.



PLAN OF GROUND FLOOR.



PLAN OF UPPER FLOOR.



TABLE A.—SICKNESSES IN JONES' FAMILY.

Name.	Age.	Date of Appearance of Measles (ailing 2 or 3 days before).	Date of First Appearance of Sore Throat.	Result.	REMARKS.
Mr. Jones	Years. 49	—	—	—	—
Mrs. Jones	42	—	—	—	—
James	17	9 or 10 years ago with whooping-cough.	Oct. 4	Recovered	Employed on farm, chiefly attending to sheep. <i>Not</i> at school-feast.
Ann Elizabeth	15	Ditto	Oct. 2	Died Oct. 11	Did <i>not</i> go to school, <i>nor</i> attend school-feast. Hop-picking from Sept. 18 to 25.
Sarah Ann	13	Ditto	-	-	This child had charge of the younger children; used to put them to bed, &c. <i>Was</i> at school-feast on Sept. 5. Attended school, but was not there on Sept. 4 on account of infection of measles at home. Taken to Rectory on Oct. 4. Hop-picking from Sept. 18. to 25.
Emily	9	Ditto	Sept. 15	Recovered	Attended school; not there on Sept. 4 on account of measles at home. Was at school-feast on Sept. 5; had been working (making "bands") in harvest field from Sept. 1 to Sept. 15 (the 14th was on a Sunday). Felt ill when in field on Sept. 15. No medical attendant. Taken to Rectory on Oct. 4 convalescent.
Edwin	8	Sept. 3. (sickening Aug. 31)	Oct. 1	Recovered	Attended school; absent Sept. 1, began to sicken day before. Not at school-feast on Sept. 5, being ill with measles.
Edith	7	Sept. 5	Oct. 2 (first seen by Dr. Pope)	Died Oct. 10	Attended school; absent Sept. 4 like the rest. Not at school-feast on account of measles. Having recovered, hop-picking from Sept. 18 to Sept. 25.
William Henry	6	Sept. 3 (sickening on 1st)	Oct. 1 (ditto)	Died Oct. 7	Attended school, but absent Sept. 2 to 4 like the rest. Not at school-feast on account of measles.
Mary	4	Sept. 15	Sept. 28 (Sunday evening)	Died Sept. 29	Attended school, but absent Sept. 3 and 4 although not ill. Between measles and diphtheria on 28th said to have had "croup," to which she is said to have been subject. Not at school-feast.
Ellen	3	Ditto	About Oct. 4 (only slight sore throat).	Recovered	Does not attend school. Not at school-feast on Sept. 5.
Thomas Frederick	1 year and 11 months.	Sept. 7 (according to Sarah Ann; but Dr. Prall says he had a measles eruption when he saw him on 30th Sept. which he called "Rubeola notha.")	Sept. 30 (Dr. Prall says there were deep ulcerations and enlarged glands).	Died Oct. 6	Did not attend school.
Madeleine } Winifred }	3 months	-	Sept. 29 (but Madeleine probably earlier, since Dr. Prall saw membrane on that day on her throat).	<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;"> Died Oct. 2 Died Oct. 3 </div> <div style="font-size: 2em;">}</div> </div>	{ Last seen, Oct. 1; they were 8 months children, and very delicate; fed from breast and new cow's milk from a bottle.

